Benefits Pool Discussion: The Challenges of Modeling Future En Route Enhancements

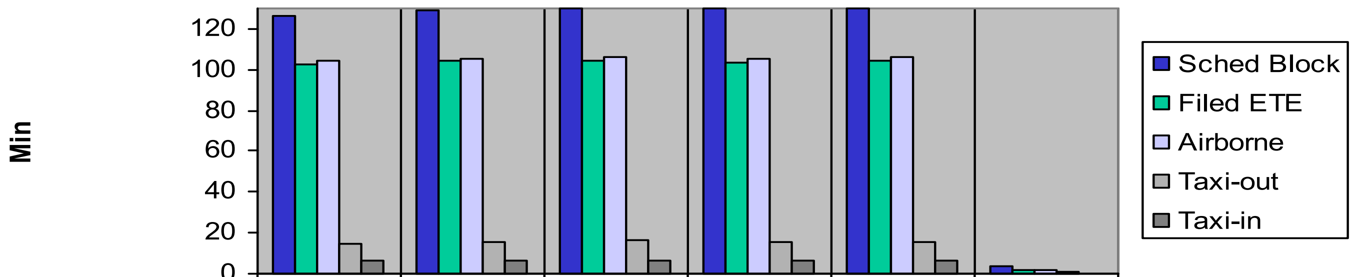
Presented by
Dan Citrenbaum
Federal Aviation Administration
Operations Research and Analysis Branch, ASD-430
March 12, 2003

En Route Inefficiency Measurement Issues

- What metrics should we use when describing the "en route pool"?
- How do we define an "upper bound"? "reasonable bound"?
  - Good weather day(s) – constrained system
  - Good weather day(s) – unconstrained system
  - Combination of good/bad days – constrained system
  - Combination of good/bad days – unconstrained system
- What are the primary variables that require a high level of granularity and accuracy when estimating benefits through a program's life cycle???
  - Type of aircraft, fleet mix, equipage, weekday/weekend, weather (convective and ceiling/vis), O-D pairs, traffic volume, etc.
- What are the limitations and weaknesses in our models when we attempt to capture the future capabilities articulated in the NAS Concepts of Operations, OEP and NAS Architecture?

What are the Historical Performance Trends?

Number of Instrument Air Carrier Operations from 1998 to 2000 increased by 9.0 percent; from 1998-2002 the operations decreased approximately 2.8 percent. Source: ATADs



	1998	1999	2000	2001	2002	Diff (98-02)
Sched Block	126.6	128.7	130.1	130	130.2	3.62
Filed ETE	102.6	104	104.8	103.4	104.2	1.59
Airborne	104.3	105.6	106.5	105.1	105.9	1.65
Taxi-out	15.1	16	16.5	15.8	15.7	0.6
Taxi-in	5.98	6.21	6.41	6.48	6.36	0.38

Source: ASQP, CODAS (1998-2000) and ASPM (2001 and 2002) output based on 2,300 + identical O-D pairs, 5M+ records per year

From 1998-2002

- *Airborne time increased by 1.5%; Block times increased by 2.8%;Taxi-times increased by 9.6%*
- *The Estimated Time En Route (ETE) to Airborne time differential was virtually identical (1.6 to 1.7 minutes) for each year.*
- *The airborne time increases are primarily due to volume congestion at the airport*
- *OPSNET en route delays are approximately 1 percent of total OPSNET delays*

Another Way of Looking at Airborne Times

Airborne Time (Source: ASQP – 2300+ city pairs)	YEAR							
Percentile	95	96	97	98	99	00	01	02
25th	95.2	96.6	97.5	98.4	99.8	100.7	99.6	100.2
50th (Median)	99.4	100.8	101.9	102.8	104.1	105.2	103.9	104.7
Diff (50 – 25)	4.2	4.3	4.4	4.4	4.2	4.5	4.4	4.5
AC Instrument Ops Traffic Increase Relative to 1995		0.8%	6.2%	7.5%	14.3%	17.1%	10.6%	5.0%

- ***The 25th percentile in 2002 is comparable to the 50th percentile in 1996***
- ***The 50th percentile of airborne time from 1995 to 2002 has increased 5.3 minutes as traffic has increased 5 percent***

- How much can we close the gap in the future? Can we close the gap in the future?
- Can we mitigate the longer times as traffic increases?
- How will the total benefit be assigned from the following programs and/or NAS initiatives that are claiming **user benefits**:
  - URET, CPDLC, TMA, CRCT, NEXCOM, TFM, ADS-B Multilateration, DVRSM, RNP Procedures, WAAS, LAAS, establishment of RNAV routes, ITWS, MIAWs, TDWR, upgraded terminal radars (ASR-9, STARs), PRM, DSP, and procedural changes

Programs/Capabilities that are Expected to be Part of the Benefit Pool
(Delay and Flight Efficiency Savings)

Program/Capability	En Route	Terminal	Surface	Program/Capability	En Route	Terminal	Surface
ADS-B	X	X	X	Medium Intensity Airport Weather System (MIAWS)		X	
ASDE-X, ASDE-3			X	Power Systems	X	X	
CPDLC	X			Precision Runway Monitor (PRM)		X	
CRCT	X		X	Additional RNAV Routes	X	X	
En Route Communications Gateway (ECG)	X			Radio Frequency Interference (RFI)	X	X	
ERAM	X	X		Required Navigation Procedures (RNP)	X	X	X
Departure Sequencing Program (DSP)		X	X	Terminal Radars (ASR-9 SLEP, TDWR)		X	X
DRVSM	X			Traffic Flow Management (TFM)	X	X	X
Integrated Terminal Weather System (ITWS)		X		TMA		X	X
Local Area Augmentation System (LAAS)		X		URET	X		
NEXCOM	X	X		Wide Area Augmentation System (WAAS)		X	
NAS Infrastructure Management System (NIMS)	X	X	X	Winds Aloft Prediction in Non-convective weather	X		

Common Tools to Analyze En Route Delays

Models/ Data	Type	Primary Users	How En Route Delay is Measured
DPAT	Discrete-event (NAS level)	CAASD, ATCSCC, AOZ	En Route sector queues 1) entry delay of aircraft that entered sector during 15-minute interval, 2) exit delay of aircraft that waited in the current sector for entry into next sector, 3) fix delay – total time aircraft in sector were delayed waiting for a fix restriction, i.e, a MIT restriction, 4) dynamic flow restrictions (interaction between adjacent sectors)
NASPAC	Discrete-event (system level)	FAATC, ASD-400	Same as DPAT except exit delays are not calculated.
RAMs	Discrete-event (regional level)	Eurocontrol, ASD-430/SETA, CSSI	Based on additional time when aircraft are resolving conflicts
AWSIM	Time-based continuous flow tool (NAS level)	AEROSPACE Inc and FAATC (Human Factors Group). ACB-330 and ASD-400 currently evaluating it	Measures en route delays by comparing the time of flight in the sectors through sector analysis metrics tool
POET	Data analysis tool	FAA, Airlines	Various metrics based on comparing filed en route time and actual airborne differences from ETMS messages
ASPM (data)	Data source that integrates ASQP, ETMS, OAG, ARINC	FAA, Airlines and Industry	**Airborne delay** measured based on difference between filed ETE and actual airborne time. Reportable through APO-130
Others: SDAT, TAAM, FACET, etc.			

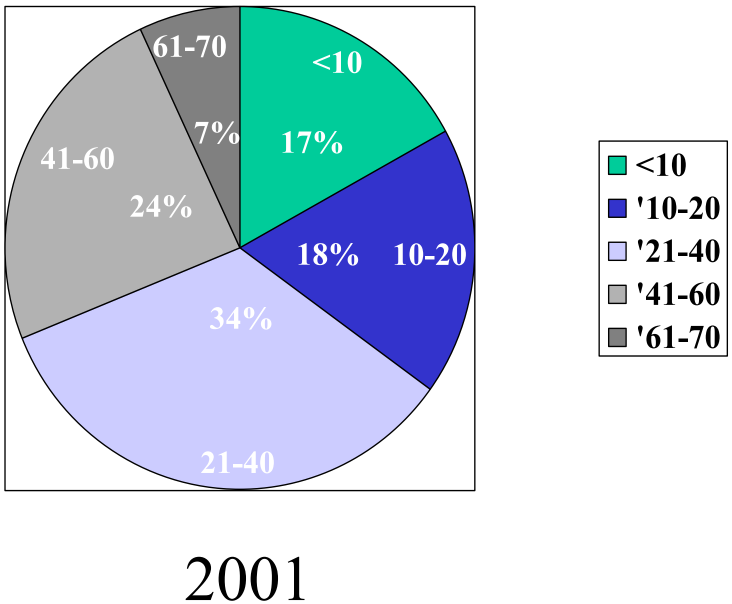
Primary Modeling Challenges When Estimating Future En Route Benefits

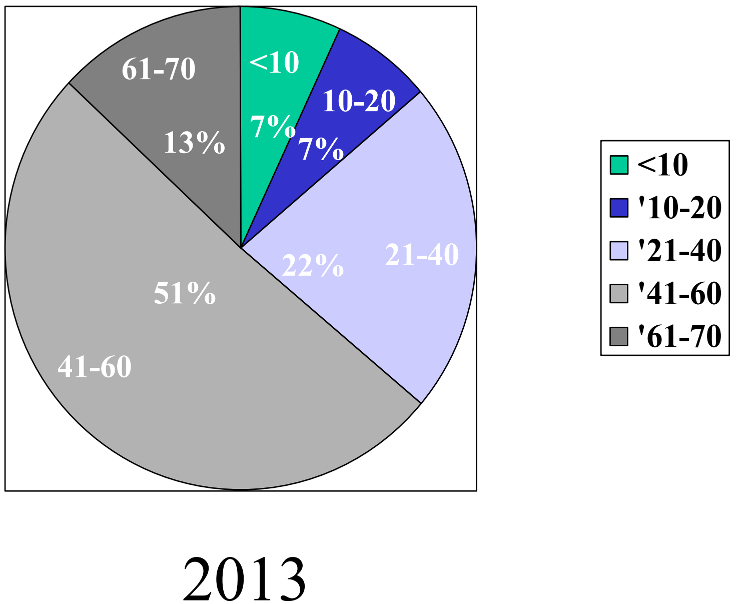
Key Variables	What ASD-400 Did in Southern Region Study	Issues
Fleet Mix	1995 Boeing Forecast with minor adjustments	Need to ensure there is consistency with APO by economic value class, and ac types.
Equipage	Used aircraft that could fly advanced RNAV routes per FAA Air Traffic Order 7110.65	How do we time-phase equipage for data link, RVSM, ADS-B, advanced RNAV, RNP, etc.?
Future Demand	NASPAC Future Demand Generator (FDG)	How does the logic vary between other models (i.e., DPAT, CSSI FDG)?
Future Capabilities	Certain set of aircraft had varying types of equipment (i.e., GPS, advanced FMS, RVSM to fly direct/optimized flights)	How consistent are we identifying the *eligible flights* that can benefit from future capabilities identified in the OEP?
Conflicts	Flew aircraft with no conflict resolution using optimized trajectories from OPGEN. Reported conflicts by duration and altitude	Should incorporate conflict resolution when optimizing flights for varying separation criteria?
Future Airspace Redesign Initiatives	No adjustments	Airport redesign initiatives, which are well-defined through 2006 need to be reflected in the scenarios.

Modeling Challenge
Example 1: Airspace Redesign

- Are we capturing the initiatives in our modeling scenarios?
- Are the organizations developing National Airspace Redesign (NAR) and High Altitude Redesign (HAR) involved in our modeling processes?
- How are we changing the sector configurations to be consistent with the ongoing airspace alignments in the ARTCCs?
- Initiatives include:
  - HAR – Phase 1 Completion scheduled by 2005
    - Impacts airspace at/or above FL390 in 7 ARTCCs; above FL350 in 7 additional ARTCCs
    - HARs objective is to provide users with additional opportunity to operate preferred profiles at more efficient altitudes
  - Phase 2 Completion scheduled by 2007
    - Per OEP, several HAR initiatives depend on phase 2 concepts such as reduced RNP values
    - Infrastructure is key to effectively support the high altitude concept (e.g., ERAM to make changes in ground based functionality)

Modeling Challenge
Example 2: Fleet Mix
Regional Jets and Commuters





Source: FAA Aerospace Forecasts, FY2002-2013, March 2002

- Are we consistently reflecting the growth in the different types of these aircraft (e.g., CRJ100/200, Dornier 328, E135, E145, etc.) in our future scenarios???

ASD-400's Next Steps
(Short-term)

- Estimate upper bound pool on good weather day by end of March
  - Will provide ASD-400 with an "efficiency" position before upcoming JRCs (i.e., CPDLC, TFM, and ERAM)

  <u>Fuelburn Savings (CSSI Support through SETA Contract)</u>

  - Take different days, e.g., absolute best day (based on reported delays, flight times and weather criteria)
  - Run set of trajectories through OPGEN and compute the average fuelburn savings per flight improvement for wind-optimized flights
  - Identify fuelburn-to-time relationship

  ==

  <u>Flight Time Savings (FAATC Support)</u>

  - Combination of NASPAC simulation with data checks based on multiple year trends
  - Will provide delays by ground, en route and terminal, block, and arrival delays
  - Leveraging off of the ERAM Investment Analysis work for upcoming JRC

- ASD-400 and FAATC are evaluating AWSIM (Aerospace Inc.) model
  - Shows potential to fill some of the shortcomings of DPAT and NASPAC
    - Includes fast response to modeling dynamic resectorization, moving weather cells, separation changes, etc.

ASD-400's Next Steps
(Mid-to-Long Term)
Estimate Realizable Benefits in Bad Weather Conditions

- Evaluate good weather and bad weather scenarios
  - Leverage off ARQs weather portfolio work that identified several weather packages
  - Several potential initiatives within the following "weather packages" are expected to have delay and efficiency benefits
    - **Delay benefits packages**
      - Thunderstorm Impact Mitigation
      - Obstruction to Visibility Impact Mitigation
      - Mitigation of Snow and Ice on Ground Operations
      - Wake Vortex Configuration
      - Efficient Airport Reconfiguration in Response to Wind Changes
    - **Efficiency benefit packages per ARQ**
      - Non-convective turbulence and winds aloft predictions
- Run simulation for both good/bad weather scenarios
  - Compare differences with the historical data
  - Current data shows approximately 5 minute block time difference between 15th percentile and 90th percentile day for 16,000 flights to same city pairs; in IMC, the data shows 5-7 minute difference between delays during IMC and delays during VMC; 9-11 minute difference in arrival delays
    - How much of the gap can be avoided (i.e., what piece of the bad days)???

Questions and Feedback